INTEGRATED PEST MANAGEMENT IN AND AROUND BUILDINGS

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I. INTRODUCTION

Integrated Pest Management (IPM) is defined as the "use of all appropriate technology and management practices to bring about pest prevention and suppression in a cost-effective, environmentally sound manner." This concept emphasizes non-chemical control techniques over chemical controls and not the total elimination of pesticides.

Although IPM has been implemented in DoD pest management programs for many years, renewed emphasis is needed. DoD's strategic plan for environmental security, drafted in 1993, mandates a reduction in the environmental risk from pesticides used in DoD programs. The proposed strategy to accomplish this goal includes expanding existing IPM practices. We expect IPM:

- To minimize harm to human health and the environment
- To reduce the need for pesticides
- To reduce pest resistance
- To minimize pesticide waste

It is incumbent upon all personnel involved in military pest management programs to actively support IPM initiatives and provide resources for implementation. This includes trained Pest Controllers (PC), Pest Control Quality Assurance Evaluators (PCQAE), Pest Management Consultants (PMC) and managers and supervisors responsible for real property, food services and custodial services. It has never been more important for Pest Management Consultants to ensure that IPM strategies and methodologies are incorporated into installation pest management plans, installation program reviews and contracting processes, training for DoD Pest Controllers and Pest Control Quality Assurance Evaluators.

This is not a cookbook on IPM. The purpose here is to present a sampling of techniques and procedures to illustrate the facilities management approach to pest control. All of the methods cited have been tried previously, and all have proved successful in real-world situations. But since buildings vary enormously, no method will work equally well in all circumstances. The challenge of IPM is that it often cannot be delivered by formula. Once the basic principles have been understood, there is no substitute for resourcefulness and ingenuity in developing practical, site-specific pest management solutions. Another objective of this document is to illustrate the variety of control techniques that can be used in Integrated Pest Management.

This Memorandum may never be completed; to include all possible methodologies would greatly delay the publication of any IPM guidance. Additionally, specialized

buildings such as health and dining facilities, infestible storage or warehouses and prisons are not included, although many of the same IPM principles still apply.

Outdoor IPM programs will be addressed in future publications. Excellent opportunities for implementing IPM already exist in the control of weeds, turf and ornamental pests, forest pests, and disease vectors.

II. GENERAL GUIDANCE

Unique Program. The elimination and prevention of pests in buildings is a distinct facilities services program, not just a custodial function, whether performed by in-house forces or by contract.

Program Scope. Modern pest management begins with the planning, design and maintenance of buildings. Once buildings are constructed, inspections often reveal pest problems. All personnel responsible for cleaning and solid waste management programs must contribute to effective pest management. IPM is truly a multi-disciplinary function.

Concerns of a Modern Pest Management Program. Modern pest control has evolved into a complex and specialized discipline that includes the application of pesticides. Chemicals are still important, but property managers are now faced with increasing public concern about pesticide misuse, toxic materials in the workplace, and increasingly restrictive regulation. Safer chemicals and treatment methods are continually being developed and should be incorporated into pest control programs whenever possible. At the same time, program managers must be aware that numerous products are ineffective or require special skills to be used effectively. The old-fashioned type of pest control that consisted of spraying around buildings and chasing cockroaches from one place to another is ineffective, potentially hazardous, and an unacceptable liability and public relations risk.

Integrated Pest Management and Old-fashioned Pest Control. The modern method of pest control is often termed Integrated Pest Management, or IPM. IPM methodology includes:

- Identifying specific pest infestations
- Controlling these infestations with short-term solutions including pesticides
- Reducing or eliminating the causes of infestation with long-term solutions such as structural modification

IPM methods must be safe and cost-effective. The critical components of IPM programs include cleaning, solid waste management, structural maintenance, pesticide application, and occupant education. IPM differs from old-fashioned pest control in many ways (Table 1).

Attributes of IPM Programs are:

Proactive Program. Old-fashioned pest control methods tended to ignore the causes of pest problems, and instead reacted and temporarily removed a small part of the infestation with chemicals. Although IPM also includes an immediate corrective response that may employ pesticides, it is mainly a preventive maintenance process that controls pests by reducing their food, water, harborage, and entry points. Hence, it is imperative that IPM begin with the structural planning and design process.

Management Process. Old-fashioned pest control relied on the "exterminator" to solve pest problems, often without a Pest Management Professional determining what services were needed and the type of control desired. Lasting solutions usually depend on coordinated initiatives to upgrade sanitation, housekeeping and repair.

Minimal Pesticide Use. Old-fashioned pest control consisted of routine pesticide application whether pests were present or not. IPM consists of routine inspection and monitoring, but treatment only when pests are actually present. Scheduled, repetitive pesticide treatment without regard for pest population dynamics is ineffective and environmentally unsound. IPM can reduce the potential for liability resulting from ecological insults or adverse effects on human health.

Least Toxic Treatment. Non-chemical control alternatives should always be considered before the use of pesticides. Old-fashioned pest control included the application of excessive amounts of pesticides to exposed areas far from where needed. Baseboard spraying and room fogging is still widely practiced by some in the pest control industry. These techniques are not very effective for killing cockroaches and other insects that live deep within furniture, equipment, or structural elements. IPM requires that pesticides, when needed, be applied with precision and restraint. It emphasizes that only the safest compounds, formulations, and methods of application are appropriate. Insecticide baits are usually preferable to sprays. Sprays, when necessary, should be limited strictly to "crack and crevice" applications. Space sprays and fogging are reserved for unusual situations where no other solution is practical.

Technical Expertise. Old-fashioned pest control technicians did little except operate compressed air sprayers. IPM requires a much higher standard of in-house and contractor expertise to be successful. It is essential that managers have informed technical guidance on all aspects of the pest control effort.

The Pest Management Consultant (PMC). In-house or commercial pest control services that still employ old-fashioned methods, primarily scheduled spraying, cannot be relied on to provide service or advice that is in the DoD's best interests. To ensure that pest control in DoD buildings meets the highest standards of safety and effectiveness, the PMC at major command or regional level serves as the installation advisor on pest management. The PMC's office functions as an information center on pest biology and identification, pest control technology, pest control contract administration, and pesticide law. The installation environmental coordinator, pest management coordinator, pest control supervisor and other installation personnel are encouraged to use this resource as part of their "team". If you require assistance in determining who your PMC is, you may call DPMIAC at the AFPMB. The major command or regional PMC is available to prepare pest management plans, review installation programs on-site, conduct training workshops for installation personnel, and consult on special problems. Increasingly, these services require reimbursement.

Getting Started: The Six Steps of the IPM Process. The IPM process is mostly common sense. The challenge lies in having enough patience and skill to gradually replace old attitudes and habits. Each pest problem, great or small, usually presents the pest controller with six basic tasks:

- Understanding and Educating the Customer**.** Most pest control in and around buildings is a service to the occupants and is performed at their request. The IPM process therefore typically begins with people rather than pests. Customer relations is always a two-way street. Educating the customer about pest management is essential, but it is much more effective if the pest controller first understands customer concerns and expectations. Education begins by explaining whether or not the concerns are warranted and the expectations attainable. As in any service occupation, the ability to listen to and communicate with people is absolutely essential.

    - Analyzing the Pest Problem**.** It is fairly simple to identify most pests and why they are present, but a thorough understanding of structural engineering and design may be needed to determine the source of an infestation.

    - Taking Short-Term, Corrective Action**.** Although IPM emphasizes a "preventive maintenance" approach to pest problems, the real world often demands immediate corrective action. In many cases, the use of pesticides for this purpose is unavoidable. However, all concerned must understand that every corrective action will employ the least toxic method.

    - Implementing Long-Term, Preventive Action**.** Ongoing, "built-in" control actions indirectly reduce pests by minimizing their food, harborage, and access. These actions are the heart of the IPM process and a

fundamental measure of its success. Sanitation and exclusion may be difficult to plan, coordinate, and execute but are critical for success. Pest prevention, the "applied facilities management" aspect of IPM, requires that the pest controller have as thorough a knowledge of building operations as of pest biology. For IPM to work, those responsible for sanitation and building maintenance must cooperate with the pest controllers.

- Monitoring, Documenting, and Evaluating Results**.** DoD pest control reporting systems include options for non-chemical control. Accurate record keeping is necessary to document IPM successes.

- Getting Back to the Customer**.** Measurement of customer satisfaction is easy to ignore, but critical for program viability. The pest controller's own performance evaluation may not totally coincide with the opinions of others who are more directly affected by the pest problem. Customer satisfaction is a prerequisite for program support.

CONTRASTS BETWEEN OLD-FASHIONED PEST CONTROL AND IPM FOR BUILDINGS

Element	Old-Fashioned Pest Control	Integrated Pest Management
Program strategy	Reactive	Preventive pest control
Customer education	Minimal	Extensive
Potential liability	High	Low
Emphasis	Routine pesticide application	Pesticides used when exclusion, sanitation, etc. are inadequate
Inspection and monitoring	Minimal	Extensive
Pesticide application	By schedule	By need
Insecticides in occupied spaces	Sprays & aerosols	Baits
Application of sprayed insecticides	Surface treatment	Mostly crack and crevice

Use of insecticide space spraying & fogging	Extensive	Minimal
Rodent control	Emphasis on rodenticide	Emphasis on trapping, sanitation and exclusion
Bird control	Emphasis on avicide	Emphasis on exclusion

III. INSPECTION

General Inspection Considerations. Most pest problems in a building are discovered and reported by the occupants. Installation and contractor inspection of specific areas where pests have been reported should provide answers to these questions:

- How are the pests getting in, and can this access be reduced or eliminated?
- What food source or other attractant has drawn the pests and can this source be reduced or eliminated?
- Where exactly are the pests living, and can these sites be physically altered, removed, or treated with traps or chemicals?

IV. CONTROL TECHNIQUES

Common Pest Problems. The following paragraphs describe common pest problems in DoD buildings and the techniques for dealing with them. These general guidelines can be used when preparing contract specifications. Special circumstances may arise that require alternate or modified approaches. Consult a PMC for additional information. Pest management information bulletins should be distributed to tenants with questions about the pest control program.

Rats

Rats dig burrows around foundations, in earthen banks and in planting beds. They are attracted to debris and food in unsecured waste storage containers. Rat problems originate outside the building. Rodents usually stay at ground level and below but, if they gain access to wall voids, may climb to upper floors. Rat control starts with three principal operations that do not involve the pest control contractor: sanitation, housekeeping and structural maintenance. These operations are generally more important than trapping and poisoning.

Securing Garbage and Trash. Since trash may contain food scraps attractive to rats, all collected waste must be stored for pickup in ratproof containers or kept in a ratproof room constructed of materials that cannot be easily gnawed. Rats can penetrate gaps greater than 1/2 inch. Compactors should be of a self-contained design and equipped with protective doors that close over the charge box.

Eliminating Unnecessary Storage and Debris. Building grounds, loading docks, and interior space at street level and below should be kept as free as possible of debris that rats can use for shelter. Anything soft, such as rolled carpeting, insulation, or padded furniture, is particularly attractive to rats.

Eliminating Access To Buildings. Rats commonly enter buildings through open or poorly fitted doors and windows, unscreened vents, cracks in masonry, or holes gnawed in weatherstripping or where utilities enter buildings. Pest controllers should report these conditions to facilities maintenance or public works. Contract specifications should require contractors to notify the contracting office when conditions contributing to pest problems are observed.

Bait boxes. Rodenticide baits are normally effective only if there is little alternative food for the rats. Sanitation, therefore, is a prerequisite for baiting. Although pest control contractors often place bait boxes around building exteriors, their use on DoD property is not recommended unless other control measures have failed or are impractical. All bait boxes on DoD property should conform to the following EPA guidelines:

- Box anchored in place so that it cannot be picked up
- Box lid secured with fastener or locking tie
- Box of a "tamper-resistant" design, with a protected feeding chamber and constructed of a sturdy material
- Bait placed only in the feeding chamber (not placed in box entrance or inserted into burrows)
- Box label with name of rodenticide and last date of service

All pesticides must be used in strict accordance with the label directions. Using a pesticide in a manner inconsistent with its label directions is a violation of Federal law.

Tracking Powder. Tracking powder applied deeply into burrows with a hand operated duster is one of the most effective ways of poisoning rats and may be the only way of poisoning bait-shy individuals. Treatment with tracking powders is most effective in dry weather.

Trapping. Indoor control of rats is accomplished with snap traps and large glue boards. Either may be used outdoors in protected locations. Care must be taken to place traps in safe locations and out of public view. Check traps and boards regularly.

Mice

Mice may enter buildings from the outside, but many mouse problems originate indoors. Although large numbers can build up in food service areas or trash rooms, small numbers can survive practically anywhere. Mice generally nest within 15 feet of their food source and frequently spread through a structure along pipes, cables, and ducts. The increased use of raised flooring for electric cables in telecommunications and computer facilities has greatly increased potential mouse harborage in public and commercial buildings.

Sealing Entry Points. A practical control measure for limited areas is blocking access routes into occupied spaces by sealing utility openings or chases. Young mice can squeeze through cracks just wider than one-quarter inch. Entry points can be sealed with caulk, copper mesh, steel wool, or polyurethane foam. Large, open office areas or rooms in older buildings may have so many potential access points that sealing is impractical.

Cleaning and Housekeeping. Sanitation for mouse control is similar to that required for controlling cockroaches. All food and refuse should be stored in sealed containers. Surfaces, crevices and containers should be free of food residue. Refuse should be removed daily. Strict attention to cleanliness is essential for mouse control in food service areas. However, it is often difficult to achieve a level of office sanitation that actually makes a difference for a scattered, low-level mouse infestation.

Rodenticides. Rodenticide bait or tracking powder is generally not recommended for mouse control inside buildings because of the potential odor from dead mice behind walls. In addition, there is always the chance that tracking powder applied in out-of-the-way locations may be disturbed during future renovation work.

Trapping. Glue boards and snap traps are usually the most effective devices for controlling small numbers of mice. Extreme care must be taken to conceal traps in order to avoid adverse occupant reaction. Windup, multiple-catch traps can be useful for controlling large infestations in kitchens or unoccupied spaces, provided the necessary sanitation and sealing measures are also carried out.

Small Cockroaches

Two species are responsible for most pest complaints and pesticide use in public and commercial buildings in the United States: the "German" and the "brown-banded" cockroaches, each less than three-quarters inch in length. Although it is

widely believed that these insects can never be eradicated from the workplace, it is possible to totally eliminate them from a limited area such as an office. However, the degree of success depends not only on control measures but on occupant attention to detail when it comes to cleanliness and housekeeping. Cockroaches and their egg capsules are continually reintroduced on custodial trash carts and with packaged food. These invaders will not survive and multiply if they cannot find enough to eat.

Sanitation. Cleanup to reduce cockroaches in an office environment must focus mainly on the food residue in and around coffee machines, microwave ovens, refrigerators, trash cans, and furniture where exposed food is stored. Occupants concerned about cockroaches in their workplace must understand their own responsibility for storing all food in tightly sealed containers and for cleaning surfaces on which food is prepared or consumed. Daily afternoon trash pickup is recommended. Removal of corrugated cardboard is especially important since it provides excellent harborage for cockroaches. Dedicated containers with a tight lid and a plastic liner, replaced daily, for disposal of all items will reduce cockroach problems. The most effective cockroach control technique for food service areas and trash rooms is regular steam cleaning or pressure washing of all possible structural crevices and equipment.

Caulking. Permanent reduction of cockroach populations may be achieved by eliminating harborage. A caulking gun is probably the most appropriate symbol of modern pest control. Care must be taken to completely seal the entire crevice so that cockroach access is totally eliminated. Types of space where caulk or grout are most effective include food service areas, restrooms, and janitors' closets. The most common types of cracks to eliminate include: where sinks and fixtures are mounted to the wall or floor, around all types of plumbing, baseboard molding and corner guards, where shelves and cabinets meet walls or door frames, and any cracks on or near food preparation surfaces. Care must be taken to clean surface areas around cracks before applying caulk; surface dirt can reduce the adhesive ability of caulking material.

Baiting. Containerized paste or gel baits should be the standard insecticide treatment for cockroaches in most occupied spaces. The small plastic bait containers should be placed as close as possible to the dark, concealed spots where cockroaches are actually living, preferably adjacent to edges and corners. The most common mistakes in using containerized bait are failure to eliminate nearby alternate food, and failure to use enough containers. For example, at least 2 - 3 bait stations should be placed in infested desks. Containers should be replaced after 3 months or sooner at the beginning of a baiting program if cockroaches are very numerous. The newer transparent bait stations facilitate checking baits for consumption. Paste or gel baits are most effective when applied in many small dabs, preferably with a syringe-like dispensing tool. Abamectin bait is safe and highly effective but must be carefully injected into crevices.

Crack and Crevice Spraying. Spraying is sometimes the most practical and effective way to apply pesticide in food service areas, restrooms, and trash rooms.

Spray must be precisely applied in small amounts only to cracks and crevices. A "crack and crevice" treatment implies that the stream of insecticide is never visible during the spraying process.

Sticky Traps. Many types of cardboard or plastic sticky traps are available to help the pest control technician or installation personnel pinpoint sources of cockroach infestation, or monitor areas where occupants have complained but no infestations can be visually detected. Sticky traps are not intended for control but rather to guide and evaluate control efforts as part of the inspection process.

Large Cockroaches

Several types of cockroaches grow to over an inch and a half long; these are commonly called waterbugs or, in Florida, palmetto bugs. Large cockroaches may wander along pipes throughout a building, but in temperate climates they live mainly at ground level or below. Treatment should focus on warm, moist areas such as basements, boiler rooms, pipe chases, sumps, and elevator or sewer shafts. In warm climates, even attics and mulched outdoor planting beds may be infested with large cockroaches.

Drying. One of the most effective ways to control large cockroaches in buildings is to reduce moisture by fixing leaks, improving drainage, and installing screened vents to increase airflow.

Sealing Entry Points. Cockroach access routes from wall voids into occupied spaces can be blocked with caulk or grout applied around plumbing and electrical fixtures. Caulk should be applied according to procedures outlined in Section 1.2.3.3.2. Basement floor drains should be fitted with screens or basket inserts that are cleaned regularly.

Housekeeping. In addition to eliminating food residue, reducing clutter is critical for large cockroach control. Large cockroaches like to hide in stacked boxes, cartons, rolled carpeting and any stored paper or cardboard materials, particularly in dark, damp locations.

Baiting. As with the small cockroaches, pesticide control should emphasize the use of baits rather than sprays. Consult the PMC for current recommendations.

Ants

Most species of indoor pest ants come from nests located outside the building or inside wall voids. Therefore, the most effective control typically entails sealing up cracks (usually around windows and other locations on exterior walls) where the ants are entering. Close observation on the outside often can help pinpoint these access crevices. Vegetation in contact with the building exterior, such as tree limbs or climbing

ivy, should be removed. Containerized, slow-acting bait is usually the most effective type of pesticide treatment for temporary control. Permanent control requires that the nest be located and destroyed.

Many types of ants produce winged queens and males which swarm at certain times of the year. Large numbers of swarmers may pour out of crevices into a room, even in locations that never had a problem with crawling ants. Swarming ants can severely disrupt operations and often result in occupant demands for spraying. In cases where the ants are relatively concentrated, such as at windows, they may be vacuumed and disposed of in an outdoor trash receptacle. However, in some cases, a space spray with a pyrethroid insecticide may be the only practical response. Winged ants emerging inside a building usually die quickly or disperse, so spraying tends to be of little value if not done immediately. Rooms should be unoccupied during a space spray treatment, all electronic equipment should be well covered, and the space should be ventilated for at least several hours before reoccupation. The standard procedure to prevent future swarming is to locate the ants' entry points (and the nest itself, if possible), inject a pesticide into these crevices, and seal up entry points afterwards.

There are four species of ants causing problems that require a special response after positive identification:

Pharaoh Ants. Pharaoh ants are tiny yellowish-brown to reddish-brown ants that can nest in almost any hollow place inside a building. In an office, for example, these ants could come from inside a table leg or room divider, behind a baseboard or switch plate, above the ceiling or under the floor. In warm climates, colonies may be located outside. It is important that sprays not be used for control attempts. Colonies stressed by sprays often respond by dividing. If spray is continually applied, this dividing process results in many widely scattered colonies that infest an increasingly greater area. A bait specifically labeled for pharaoh ants must be used.

Fire Ants. In warmer climates, fire ants can be a stinging hazard on building grounds, and sometimes indoors. Use of pesticides for fire ant control is usually unavoidable. Treatment often combines injection of spray into individual mounds with use of bait formulations broadcast over wider areas. Consult the PMC for current recommendations.

Carpenter Ants. Carpenter ants are large ants that tunnel in wood. Small numbers in a building may simply be invaders from an outdoor nest that can be controlled by sealing up their point of entry. Large numbers inside typically indicate a nest within the building. Carpenter ants generally prefer wood that is moist and are considered to be an "early warning signal" of structural leaks or drainage problems. Control consists of locating the nest, injecting pesticide directly into it, replacing the damaged wood, and eliminating or reducing any source of moisture.

Fruit flies

These tiny flies are introduced into buildings many times a day during warm weather, usually as nearly invisible immatures (eggs, larvae, pupae) on or in fruit. Since large numbers of these immatures can develop into adult flies within several days, and since one female fruit fly can then lay several hundred eggs, infestations build up rapidly when sanitation is not rigorous. Adult flies are easily dispersed throughout a structure by the air handling system and by hitchhiking on trash pickup carts. Although fruit flies are totally harmless and cannot bite, many people consider them an intolerable nuisance.

Sanitation. Fruit fly breeding sources are often difficult to find but eliminating the breeding sources is essential. Fruit fly larvae (maggots) require moist, fermenting material in which to develop. Typical sites that generate large numbers of flies include trash rooms and trash pickup carts, can and bottle recycling areas, and any space where food is routinely prepared, dispensed, and consumed. However, there may be dozens of smaller, local sources throughout a building that contribute to the problem. These include leaks under refrigerators, dirty mops, clogged drains, or peels and rinds left in trash receptacles.

Trapping. Fruit fly problems can be greatly reduced by the use of traps. There are many different trap designs, but all work by using bait to attract the flies into a container. Two of the most effective baits are ripe banana and vinegar. Some traps lure the flies through a funnel or similar "one-way" opening, while others rely on the collected flies eventually drowning in a liquid bait. Homemade traps can be easily fashioned from mason jars fitted with paper funnels, but several inexpensive plastic models are commercially available. Traps are remarkably effective, but problems can arise when either too few are deployed or servicing (removing flies and renewing bait) is too infrequent. An increasing number of pest control contractors are using traps as part of their normal service for fruit fly infestations.

Space Sprays. Space sprays are not recommended for fruit fly control since the potential for adverse occupant reaction to the pesticide usually exceeds any short-term benefit. However, in cases where very large numbers of flies are severely disrupting operations, a space spray with a pyrethroid-based insecticide may be the only practical response. Rooms should be unoccupied during the treatment, all electronic equipment should be covered, and the space should be adequately ventilated. If the breeding source is not discovered and corrected, sprays will only give temporary relief.

Miscellaneous Crawling Pests

Crawling insects are best controlled by sealing entry points and vacuuming intruders. Tight seals around windows, doors, utility access holes, and weatherstripping will usually reduce crawling insects. Residual insecticides sprayed on surfaces near potential entry points may be effective; microencapsulated formulations should be considered.

Spiders. Although fear of spiders is common, poisonous species are not often encountered in most general use buildings. Harmless, crawling spiders are occasionally a nuisance in basements or warehouses. Spiders that build webs in secluded corners or in outdoor locations such as eaves and lights can be removed with a vacuum.

Crickets. These insects commonly invade basements and crawl spaces, seeking dark, cool, moist areas. They are harmless to humans but may be annoying, particularly at night. They feed on organic matter and sometimes damage woolen, silk and cotton clothing and other fabrics. Field crickets usually invade buildings late in the summer when fresh vegetation becomes scarce. Closing gaps under doors and around loose-fitting windows and vents to the exterior may keep crickets out. Indoor controls should include such things as moisture reduction, sticky traps and, if necessary, a residual insecticide.

Centipedes. Most species of centipedes are harmless. To avoid contact with centipedes, two physical control methods are recommended: general cleanup of debris to eliminate their hiding places, and maintenance of close-fitting doors and screening.

Termites

Termites damage wooden structures and incidental wood in steel and concrete buildings, such as trim or molding, paneling, furring strips, or door and window frames. Files, stacked books, or any other cellulose material, such as fiberboard sheathing or insulation panels, may also be attacked. Most termite problems in large office buildings involve subterranean colonies that persist for years on buried scrap wood and constantly explore upwards for new sources of food. These colonies are often a nuisance because of the periodic emergence of large numbers of winged "swarmers" that find their way into occupied space. Swarming termites should be controlled with a vacuum cleaner. A space spray may be unavoidable in rare circumstances. All comments describing ant swarming apply to swarming termites as well.

Spot Injection and Sealing. In masonry buildings with minor termite damage or localized swarming, satisfactory control can often be accomplished with pressurized injection of insecticide directly into the wood, or into the crevices from which the swarmers are emerging. If possible, the crevices should then be caulked or otherwise sealed.

Drilling, Trenching and Fumigation. Subterranean termite problems that cannot be solved with spot injection and sealing must be treated with far more extensive insecticide application. Standard techniques involve pumping the chemical into holes drilled through the building's slab and/or into the soil around the building's foundation. In warm climates, severe infestations of certain types of termites that live in dry wood above ground (including furniture) may have to be controlled with fumigation. These

types of termite treatment require specialized contractor expertise and are beyond the scope of this chapter. Consult the PMC for additional information.

Birds

Three species of birds - pigeons, starlings and English sparrows - are serious pests when they roost and nest on or in buildings. Their excrement is unsightly, harbors microorganisms that can cause severe illness, and corrodes structural materials. Bird nests may block air intakes, damage the building surface by holding water against it, and contain parasites that can become indoor pests. Bird control is difficult and highly specialized. Consult the PMC or the installation Natural Resources Office for additional information on buildings registered under the Historic Preservation program.

Concerns of Structural Bird Control. There are three primary requirements that must be met by a bird control program:

- Maximal Effectiveness. In addition to providing long-term protection against pest birds, cost effectiveness must be considered. The utility and appearance of some exclusion devices deteriorate more rapidly than others.

- Minimal Damage to Structure. Permanent physical and aesthetic damage to any structure should be avoided in bird control work, particularly in historical buildings. Repellent systems must be harmless to building materials and finishes and must be reversible, so that if they are eventually removed the building can be returned to its original state; they must also be inconspicuous to passers-by.

- Public Relations. Even the perception that birds are being harmed is likely to draw considerable criticism from individuals, special interest groups, and the media. Bird control efforts, therefore, should always be as humane and discreet as possible.

Bird Management Methods. Several lethal bird management methods have long been used as a last resort. Although they may be appropriate in restricted or specialized circumstances, they are not recommended for large-scale projects, historic structures, or high-visibility sites. Bird management options include:

- Shooting. Shooting is an effective way to reduce starlings and pigeons in large buildings such as hangers and warehouses. A pellet rifle, or a .22 rifle with cb caps, is an effective tool for this effort. Shooting is species specific (no nontarget kills), and has no secondary toxic effects. While no federal permit is required, it is imperative that the individual marksman be trained and experienced in bird identification. To reduce adverse public

reaction, the effort should be conducted during nonduty hours by the minimum number of personnel. All dead birds should be carefully handled so as not to attract attention later. Public affairs personnel should be advised prior to the effort to prepare themselves in the event adverse attention is created. While reducing the population with lethal methods elimates the immediate problem, the potential for birds returning is high (an open niche will be filled). Periodic shooting may be required to keep bird populations at an acceptable level.

- Toxic Baiting and Toxic Perches. Control by avicides (bird poisons), either added to feed or incorporated into special perches, is undesirable in most situations - there are always more birds to take the place of those killed and adverse public reaction may result .

- Porcupine Wire. There are several anti-roosting products consisting of wire spikes or coils that stick up from ledges to prevent birds from landing. Although usually effective against pigeons if precisely installed, these materials are unacceptable for sites in public view. Their attachment to historic structures also produces an unacceptable risk of damage to masonry. Furthermore, smaller birds such as sparrows often use the wire to anchor their nests, adding to its unpleasant appearance. Porcupine wire is most useful for relatively concealed applications on utilitarian structures, such as overhead pipes and beams in garages.

- Repellent Gels. Sticky gels that birds find unpleasant can be applied to ledges with caulking guns. These gels are not recommended in most circumstances because they are eventually degraded by dust and air pollutants and are capable of staining or even spalling underlying masonry. In addition, applying sticky gels can be a messy job.

- Electrical Wire. "Shock wire" systems are not recommended in most circumstances because they are prone to shorting out when exposed to water, ice or airborne debris or during maintenance work on a building's exterior. Since these systems are typically "zoned" for large areas of a structure, a single break or short can disable hundreds of feet of wire. Like the spikes of porcupine wire, the insulators of electric systems are conspicuous and often aesthetically displeasing. Unless installed exclusively on mortar joints, with no damage to adjacent masonry, they would be automatically prohibited on historic structures.

- Scaring Devices. Plastic owls and snakes, balloons with eye patterns, brightly-colored objects that turn in the wind, and dozens of other "scarecrow" variations are intended mainly for temporary protection of crops and are almost always ineffective for protecting buildings. Falcon silhouettes may be used to prevent migratory birds from flying into large

windows. Recorded distress calls can effectively repel starlings when used by an expert. Various noisemakers, including pyrotechnics, may also be used to repel pest birds.

- Screening. Barriers and cages of hardware cloth or other wire screen are often the most efficient way to keep birds off and out of limited areas on utilitarian structures that are not in the public view. A 3/4-inch mesh is the largest size that will eliminate sparrows and starlings. Horizontal nesting areas afforded by ledges and window air conditioners can be eliminated by the use of aesthetic structural materials affixed above them and at a 45 degree angle.

- Tensioned Netting and Pin and Wire Systems. Two relatively new types of systems are the current recommended solutions for birdproofing on a large scale, on historic structures, or on any high-visibility site. "Pin and wire" installations consist of spring-tensioned stainless steel wires strung at different heights along projecting elements such as ledges, lintels, sills, and stringcourses. The wires are attached to slender, stainless steel pins inserted into mortar joints. Tensioned netting installations consist of various types of net fabrics stretched taut across recessed elements such as niches, colonnades, and the coffered ceilings of porticos. Wires or cables threaded through the net edges provide an even tension that can be adjusted by turnbuckles. The cables run through hooks or screw eyes that are attached to the building only at mortar joints. When correctly installed, both of these systems are effective, durable, and inconspicuous.

- Dangling Filaments. Migratory swallows can be deterred from nesting under roofs by an easy-to-use and inexpensive system. A 1/4-inch, 4x8 foot CDX plywood sheet is cut into strip slats 1 inch wide. Holes .063-inch in diameter are drilled into the slats at random 8, 10, and 12-inch intervals. Four-foot sections of 60-pound monofilament line are knotted at one end and then drawn through the holes to be left dangling. The slats are nailed onto wood or spot-glued onto concrete and steel using construction adhesive and installed so that the monofilament projects into the flight path of the swallows.

When areas behind the monofilament line are bright, the line is nearly invisible to birds. As birds try to land, they contact the monofilament line, which acts like netting, interrupting their flight pattern. Within 48 hours, the surprise of sudden contact stresses the birds to such an extent that they leave the area.

Removing Bird Excrement. Microorganisms that can cause serious illness live in bird droppings. However, infection typically occurs by inhaling these pathogens through the nose and mouth. Therefore, bird excrement is dangerous mainly when it is dry and subject to becoming airborne as a fine dust, particularly when disturbed by

sweeping or scraping. Germicides are sometimes applied to accumulated excrement prior to cleaning. However, thorough saturation with water and use of a respirator are usually sufficient protective measures. Many disinfectants are oil-based formulations that may permanently stain building materials. The following concepts should be incorporated in bird excrement removal on building exteriors. If possible, cleaning efforts should be coordinated with the installation of a modern birdproofing system and the removal of any old, ineffective systems that are in place.

- Worker Protection. All personnel working with accumulated bird excrement should wear a full face respirator with a High Efficiency Particulate Air (HEPA) filter for screening particles of 0.3 micron size. Dust and particle masks are better than nothing, but they will not give complete protection. In addition, all personnel should wear protective coveralls, gloves, boots, and hats.

- Application of Water. Droppings are usually easier to clean when they are dry and crusted. Nevertheless, prior to removal, all excrement must be saturated with water to prevent the debris from becoming airborne. If a hose is used on the exterior of buildings, water pressure should be low. A hand-held compressed air sprayer filled with water is also satisfactory and will reduce run-off. Higher pressures may be used for hosing small amounts of excrement off sidewalks and pavement.

- Nonmetallic Tools. On historic structures, only nonmetallic tools (such as plastic spatulas and brushes with natural fiber or nylon bristles) should be used to remove excrement. Tools that can easily damage building surfaces, such as coarse wire brushes, should not be used under any circumstances.

- Disposal. Removed excrement should be collected in plastic bags, sealed, and disposed of at a sanitary landfill.

- Public Protection. Bird excrement removal on public buildings should not be performed during normal working hours and should be scheduled for weekends, if possible. All work should be done from the outside of the building. Barricades and signage must be provided to keep the public clear of the work site during all operations.

"Paper Mites"

Pin prick-like biting sensations, usually on exposed skin and often producing inflammations that resemble insect bites, can be a persistent problem in some offices. Occupants tend to blame these "bites" on some sort of pest infestation, typically fleas (which are extremely rare in office buildings) or "paper mites" (which do not exist). The affected space is often sprayed with a pesticide in the absence of any evidence that

insects are responsible. "Paper mites" are generally a cleaning or indoor air pollution problem rather than a pest problem. Only rarely are the specific culprits in "paper mite" cases positively determined, although there are often strong suspects. Shards of fiber glass insulation (such as from batting above drop ceilings), particles from both newly installed as well as worn carpet and carpet pads, and paper dust from separating forms and computer printouts along tear-lines are some of the most common proven causes of pin prick-like irritations. The dry air of many workplaces not only makes skin more sensitive to these tiny splinters, it increases the static electricity that is responsible for the particles "jumping" onto exposed skin (sometimes the static-charged bits are mistaken for living bugs). Any activity that stirs up accumulated dust, such as office renovation or the purging of old files, often leads to a "paper mite" outbreak. In cases where there is no obvious explanation, or multiple factors are suspected, an industrial hygienist may be called in to investigate.

The Role of Management. The most common mistake of management in "paper mite" situations is to automatically request a pesticide treatment and thereby become liable in the event occupants experience adverse reactions to the chemical. The second most common mistake is for supervisors to dismiss the complaints of biting as total fabrications. Although there are cases where people imagine they are being attacked by unseen parasites, most bite-like sensations in offices involve a genuine source of skin irritation. The circumstances can be further complicated, since health care professionals unfamiliar with the "paper mite syndrome" frequently misdiagnose the resulting welts as insect bites. Others may believe that microscopic dust mites are involved. These are real organisms but cause respiratory distress rather than bites. Finally, it is normal for the coworkers of a person complaining about "paper mites" to develop a heightened sensitivity to their own skin irritations, often simply through the power of suggestion. Management must treat all concerned with sympathy and respect, but emphasize that pesticide treatment cannot be undertaken without positive confirmation that a pest problem exists.

Inspection. An inspection of the affected area should be carried out by a pest control professional who understands that pests may not be involved. Usually when real parasites are present, they are abundant and readily seen. The most common types in office buildings are mites coming from bird nests or from concealed infestations of rodents. Occasionally fleas living on guard or seeing-eye dogs will bite people who work in the vicinity. If a thorough investigation fails to produce any specimens, a nonpest cause is probably responsible. Nevertheless, it is standard procedure to monitor the area with sticky traps. In addition, occupants should be instructed to capture anything they suspect is biting them on a piece of clear adhesive tape. The PMC will identify all such samples submitted from installations. Even a single parasite specimen is justification for pesticide treatment. However, the captured items are typically bits of debris or tiny, harmless insects that are commonly present in buildings.

Inspection for Airborne Particles. When it is reasonably certain that there are no biting insects in the affected space, the pest control program is no longer involved.

Remedial Action. It is not unusual for a pesticide application to bring temporary relief to occupants with a "paper mite" problem. Part of the relief may be psychological, though sprays do settle irritating particles and decrease static electricity. Although it is unethical and sometimes illegal for pesticides to be used in this fashion, the same results can be obtained by legitimate means. A program of frequent damp cleaning, including carpet washing with water only, is often an effective short-term response while efforts are made to identify and eliminate the source of the irritation. Cleaning by vacuuming rather than wiping is not recommended; unless the vacuum is equipped with a HEPA filter, more dust may become airborne. Use of humidifiers or air purifiers can be of tremendous benefit if the affected space is not too extensive. It may be worthwhile for some employees to seek the advice of a dermatologist or other medical specialist, since techniques such as the use of moisturizers and the avoidance of harsh soaps are frequently prescribed to minimize irritation problems.

V. PUBLIC RELATIONS

General Guidance. Old-fashioned pest control did not require much understanding or support from customers. Pesticides were expected to overwhelm pests. Sometimes this happened; other times it did not. But the pest control effort operated more or less independently. Urban IPM has the potential to provide long-range, effective control with much reduced reliance on pesticides. Cooperation is required, however, because urban IPM often depends on structural modifications and sanitation performed by others. Customers must also support ongoing surveillance programs and often must tolerate slow-acting controls and occasional low-level pest sightings. Pest management professionals and activity pest management personnel should educate, sell or otherwise "convert" potential customers through a comprehensive public relations (PR) effort. They should thoroughly educate supervisors and others up through the chain of command, such as base civil or facilities engineers and installation commanders, to gain cooperation, the linchpin of success.

Acceptance of Slow-Acting Controls. Easy to use, long-lasting baits and pheromone traps are often safer and more effective than sprays but may not eliminate certain pest infestations, such as pharaoh ants or grain moths, for several weeks. Many IPM techniques may fall into the category of slow-acting controls. The servicing technician must be able to convince occupants/customers to resist the urge to "reach for the spray" even when occasional sightings occur.

Occasional sightings are common with baits and traps because, unlike "quick knock-down" agents, insects and animals frequently may be observed returning to their nests with the new-found food that baits provide.

Structural Modifications. Sometimes the need for structural modifications imposes the greatest constraint on a successful pest management program - particularly if customers and suppliers outside the pest management shop are not educated on the absolute value of these modifications. These two groups of people are often key to ensuring that such modifications are completed; however, they can balk at the cost or effort involved in this "extra" work.

Educating facility users involves pointing out pest "expressways, freeways, and hideouts" (call them what you will, but use terms that have an impact on the user) and discussing their connection to the pest problem. What one lives with on a daily basis may not necessarily be what one sees. Discussing and, more important, demonstrating the ease of caulking, taping, and repairing small, medium and large cracks and holes, while pointing out how they will aid in further exclusion, will go a long way towards helping to decrease your overall use of chemicals.

Surveillance. Although pest managers place and retrieve survey devices, it is the occupants who must live with them. Don't just install survey devices without an explanation - use the opportunity to sell your program. Taking the time to discuss the importance of surveillance - why it is often essential to proper control and should precede actual pesticide application - contributes to a truly successful IPM program.

For example, cockroaches sighted by workers may emanate from the attic, from basements or from outdoors. A full-scale application of pesticides in the working spaces will eliminate only a handful of the pests, not the source of the problem. Often explaining this to the building manager could harness their enthusiastic cooperation in your surveillance program. Tough customers might respond to a call from the command pest management professional. People are often quite amazed that others take an interest in "their" problem! Customers must protect survey devices and maintain their positions, not move them around or throw them away. They must also be willing to accept sightings, whether in or near the traps themselves. Most of all, they must accept new methods of doing business.

Lastly, successful cooperation also depends on a prompt and accurate servicing schedule by the pest management technician and correct follow-up actions once surveillance techniques reveal the problem. In essence, traps and baits must not be placed only to be ignored until the next frantic (and by now frustrated) call from the customer. Show interest in "their" problem!

Tolerance of Occasional Low-Level Sightings. Scheduled, preventive chemical control will preclude most flare-ups in pest populations. However, this method is costly, introduces unnecessary pesticides, and accelerates resistance to the chemical in use or occasionally to ones not yet introduced. Also, food service managers and others may sometimes "sacrifice" cleaning, to save money and manpower, when they expect the pest control service to come in and take care of their pest problems. And if chemicals are expected to do the trick, managers may delay or postpone the actual

long-term repair and renovation efforts absolutely necessary for proper pest management.

Sanitation. The best control programs will fail if pest management personnel cannot convince their customers to eliminate competition with alternative food sources. Prerequisite cleaning must be emphasized as the essence of the control program. The pest manager must convince decision-makers that saving money on cleaning immediately increases the costs of pest management and does not save the government money over the long term.

Design a handout specifically addressing "their" problems: that roach baits cannot out-compete grease, leftover food and standing water; rodent baits cannot out-compete uncovered garbage; full pet food bowls will probably be more enticing than a smaller, containerized bait station. Focus on "their" major problems. Consider designing a miniature poster for a particular facility, encouraging good sanitation as a method of pest control. Most people don't enjoy working around cockroaches; they just need to be convinced that they can make a difference in helping to decrease cockroach populations (as the pest management technician, you are only there to help them).

Customer Education. Pest management professional and activity personnel (pest control supervisors, quality assurance evaluators and others) should be proactive in educating customers and workers on their role in urban IPM public relations tools, which include face-to-face on-site briefings, demonstrations, newsletters and handouts.

VI. USEFUL REFERENCES

The references listed here provide useful information on specific areas of Integrated Pest Management.

GSA INFORMATION SHEETS

Bulletin No. 1. Introducing the NCR Integrated Pest Management Program

Bulletin No. 2: Cockroaches in Office Space

Bulletin No. 3. Cockroaches in Office Space II; Bait Stations vs. Spraying

Bulletin No. 4. Rats

Bulletin No. 6. American Cockroaches

Bulletin No. 7. Snakes

Bulletin No. 8. Paper Mites

GENERAL IPM REFERENCES

Guides to Pollution Prevention - Non Agricultural Pesticide Users, July 1993. EPA/625/R-93/009. Contact: Environmental Research Information/ORD, 26 West Martin Luther King Drive, Cincinnati, OH 45268-1072, (513) 569-7562. 58 pp. This document provides guidance to pesticide users in developing approaches for pollution prevention. Worksheets are included for conducting waste minimization (risk reduction) assessments.

Wood Protection Guidelines - Protecting Wood from Decay, Fungi, and Termites. November 1993. National Institute of Building Sciences, 1201 L Street, NW, Suite 400, Washington, DC 20005, (202) 289-7800. 53 pp. This document provides designers, builders, and owners with information on treated wood, soil treatment, durable species, suitable construction techniques and appropriate maintenance practices that will prevent damage from decay and termite attack. Guidelines present the most appropriate selection of protection techniques suitable to geographic location, site, and type of construction.

VII. OTHER IPM TECHNIQUES AND PROCEDURES

GENERAL GUIDANCE**.** This section provides IPM techniques and procedures that are available for use in the marketplace. **However, at this printing, some of this information is only available in outline form and will be expanded as time permits. The Real Property Protection Committee welcomes any input to complete any topic**.

Much of the specialized knowledge required for an effective structural IPM program can be more accurately described as applied facilities engineering and management rather than applied biology. However, the background of most urban entomologists and other applied biologists generally tends to be strongest in pest biology and pesticide technology. Although basic concepts of cleaning, sealing, and pest-proof storage of food and garbage are often discussed in pest control training, they are rarely presented in sufficient detail to allow a pest management professional to evaluate specific options.

The technology and procedures of the custodial, pressure cleaning, solid waste removal, and sealing industries are part of a rapidly expanding array of nonpesticidal methods that have been successfully used to combat pests in buildings. Although pesticide application is a valid and necessary part of the IPM process, one of the central tenets of IPM is to emphasize a nonpesticidal approach whenever possible.

The following outline is intended as a brief introduction to some alternatives to pesticides and illustrates some of the tools now available to the modern pest controller.

Solid Waste Management

General Housekeeping for Building Occupants. Keep sugar, cream, coffee and other foods in sealable, pest-excluding containers. Refrigerate other foods. Do not store food in desks. Have a dedicated container available in food areas for food remains. Employees should be educated to use these (labeled) containers for food wastes.

Trash Receptacles. Discussion items for this topic should include: designs and materials for interior and exterior use and problems with usage; designand distribution of dedicated containers for food residues; plastic liners and mil recommendations for general use, recycling containers, etc.; custodial maintenance and cleaning of receptacles.

Trash Collection. Discussion items for this topic should include: custodial pickup schedules; design, use, and maintenance of mobile drums and utility carts; trash chutes.

Trash Holding Areas. Discussion items for this topic should include: trash rooms, recycling holding areas, compactor zones at loading docks, refrigerated holding rooms; general recommendations for location, design and management.

Noncompacting Holding Containers. Discussion items for this topic should include: the differences between conventional rear load and container service, cans and other receptacles for rear load service, front end load dumpsters, open top debris service.

Compaction Equipment. Discussion items for this topic should include: stationary vs. self-contained; various self-contained designs, including double-rams for recycling programs, vertical packing models, small-volume indoor models; pad, access, space, and electrical requirements, including waste volume formulas and standards to determine correct compactor size; "doghouses," multicycle control systems, interlock switches, pressure gauges; the problem of tampering by personnel.

Odor Reduction. Discussion items for this topic should include: ozone generating units; non-ozone odor reduction technology, e.g. granular products, spray systems. Optional ozone generators may be attached to the compactor at additional cost. Ozone is a powerful oxidizer that breaks down odor molecules and converts them into water vapor and other odorless, harmless gases. Ozone generators contain all the electronic equipment and fans needed to generate ozone automatically using a low-wattage "corona discharge." The most common generators do not require the

addition of chemicals and only incidental, routine service. Odor reduction reduces attractiveness to pests.

Grease Storage. Discussion items for this topic should include: equipment and procedures.

Solid Waste Management Information Sources. Trade journals such as *Waste Age*, *Biocycle*, and *World Wastes* are replete with articles and advertisements on solid waste management procedures and equipment. *Waste Age* magazine provides an annual "Industry Yellow Pages," which is a consolidated source of information on waste industry services and equipment. *Waste Age*, P.O. Box 8908, Boulder, CO 80328-8908.

Cleaning

Discussion items for this topic should include: basic review of sanitation and cleaning problems, procedures and inspection for various facilities; general custodial contractual overview and relationship with solid waste management programs; the limitations of traditional cleaning methods; resources of the Cleaning Equipment Manufacturers Association.

Steam Cleaning. Discussion items for this topic should include: various designs, capacities, and uses, with particular emphasis on compact, portable equipment for kitchens, trash rooms, pallets, etc.; electric models, handheld vs. wheeled, various attachments; centralized, wall-mounted systems.

Hot Pressure Washing. Discussion items for this topic should include: various designs, capacities, and uses, with particular emphasis on compact, portable equipment for kitchens, trash rooms, pallets, etc.; electric models, handheld vs. wheeled, various attachments; centralized, wall-mounted systems.

Cold Pressure Washing. Discussion items for this topic should include: various designs, capacities, and uses, with particular emphasis on compact, portable equipment for kitchens, trash rooms, pallets, etc.; electric models, handheld vs. wheeled, various attachments; centralized, wall-mounted systems.

Cleaning Agents. Discussion items for this topic should include: the issue of disinfectants (cf. GAO/RCED-90-139 EPA Lacks Assurance Disinfectants Work) and the use of other additives, e.g. soaps and caustic degreasers.

Air Purification Equipment. This item is of importance for "paper mite" and dust mite remedies.

Sealing and Exclusion

Permanent sealing of pest harborages and runs will reduce populations of pests such as cockroaches. The long-term benefits of sealing are reduced pest control costs and reduced reliance on pesticides. Sealing techniques can be used to eliminate cracks and crevices in offices, food areas, loading docks, machine areas, etc. Typical areas that can be sealed include joints between different elements of construction, expansion joints, foundation cracks, utility runs, wall-floor junctions, door thresholds, window frames, rolled edges of stationary equipment, floor molding, bumper rails, etc. Energy conservation literature is an excellent source for techniques and procedures.

Caulking and Related Sealing Products. Since there are many types of caulks on the market, the label should be read prior to use. Some caulks are flammable and can cause respiratory and dermal distress. Joints larger than 1/2 inch wide and 1/2 inch deep should first be stuffed with fiberglass insulation, plumber's oakum, copper gauze, or similar filler. Preparing surfaces in accordance with the product label is the most important step in successful caulking. Dust, grease, old caulk, and paint chips should be removed. The surface should be cleaned with water or specified solvent and then primed to ensure adhesion.

A 10 oz. tube of caulk covers 96 linear feet to a width and depth of 1/8 inch or 24 linear feet to a width and depth of 1/4 inch. A caulking gun is recommended for most work but rope cords or tubes may be used for small jobs. Electric cordless guns or industrial equipment can be used for the larger jobs.

The construction materials to be treated and other local conditions (heat, humidity, need for elasticity, etc.) will determine which type of caulk should be used. Oil-based caulks are inflexible and short-lived. Water-based acrylic latex applies easily and dries quickly. Some can be painted almost immediately. Butyl rubber seals very well and resists water. A stringy appearance may preclude use where appearance matters. Silicone, a good multipurpose material, is easily applied with a caulking gun, adheres to most surfaces and is unaffected by moisture and UV radiation. Silicon acrylic latex can be used outdoors as well as indoors. Caulk is available in white, clear, and various colors.

PMCs or the Armed Forces Pest Management Board can provide additional information that has been prepared by the National Pest Control Association and the USACOE.

Waterproofing Membranes. Discussion items for this topic should include: bituthene and similar materials. FCGS 07111, CEGS 07111-3-82.

Weatherstripping. Discussion items for this topic should include: materials for crevices, e.g. extruded polyethylene rope, wax-polymer adhesive cords, sealing tapes, etc.; seal, sweep, and threshold products for doors, including overhead rolling and hangar doors, rubber, synthetic, and bristle designs.

Metal and Metal Fabrics. Discussion items for this topic should include: gauges for ratproof sheet and expanded metal; steel wool, Stuf-fit copper mesh, rolled hardware cloth.

Concrete and Cement. Discussion items for this topic should include: various small-volume products and procedures; correct mixtures and thicknesses for ratproofing; cap blocks for concrete block walls; rapid setting cements, ASTM C-928.

Screening, Grills, and Plugs. Discussion items for this topic should include: gauges for ratproof hardware cloth & other materials, mesh sizes for screens; include design and installation of window, door, vent, and intake screening, basket screens and sleeves for floor drains, dumpster drain hole screens, plugs for weep holes, hinged anti-rat plugs for toilets.

Air Curtains. Discussion items for this topic should include: design, installation, and maintenance.

Strip Doors. Discussion items for this topic should include: penadore hanging strips and other products.

Rat and Squirrel Guards. Discussion items for this topic should include: flat, disk, cone, barrel, and rotating tube designs for pipes, cable, and wires.

Bat Exclusion. Discussion items for this topic should include: basic procedures; various checkvalve designs and applications, e.g. draped netting & one-way net doors, funnel cone/chute devices, collapsible pipes or bags; use of smoke generators, air flow indicators, and other devices to find access holes. For detailed information see Prevention and Control of Wildlife Damage, Robert Timm, ed., Great Plains Agricultural Council, Wildlife Resources Committee, Nebraska Cooperative Extension Service, ISBN 0-9613015-0-3, SF84.4.P74, 1983, and House Bat Management, Arthur M. Greenhall, U.S. Department of the Interior, Fish and Wildlife Service, Resource Publication 143, 1982.

Ventilation and Indoor Drainage

Soffit Vents. Discussion items for this topic should include: the Brenner design and others.

Other Vent Designs. Discussion items for this topic should include: floating shuttle and hinged flap products.

Sump Pumps and Other Problem Areas. Discussion items for this topic should include: procedures for excluding pests from sump pump areas; identification of other problem areas amenable to IPM.

Designing for Pest Management

Outdoor Lighting**.** Pest problems in and around buildings can be reduced by proper selection and placement of outdoor lighting. Many nocturnal flying and crawling arthropods are drawn to exterior lighting. Once attracted, they find their way into buildings through cracks and crevices and open doors.

Bulbs vary in brightness or intensity and associated heat. Reducing wattage or luminous area (reflectors) will reduce light and heat, making the bulb less attractive to insects. More heat is generated by standard filament bulbs and flood lights than by sodium vapor or fluorescent bulbs.

The color and type of light are also important. Lights with mercury vapor or fluorescent bulbs produce much higher levels of insect-attracting ultraviolet (UV) light than do sodium vapor lamps. Generally, the wavelengths of light attractive to most insects are in the 330 to 370 nm UV range. Switching to high pressure or, even better, low pressure sodium vapor bulbs will make lights much less attractive to insects. More insects are attracted to white incandescent, blue mercury vapor, and fluorescent lights than to yellow light produced by sodium bulbs. Since the sodium lamps change perceived colors to yellowish, pinkish, brownish, or gray tints, sodium lamps should only be used where color definition is not important.

Lights mounted on buildings near entrances can be moved and placed on poles away from buildings. If lights can't be moved from entrances, they should be used only when needed. Lights away from buildings can be blocked in the direction from which insects typically come, and the light can be directed toward important building zones to minimize attracted pests. Bright white lights (spotlights), UV, or mercury vapor lights attract insects; they may be placed 150 to 250 feet from buildings to attract some pests away from the structures themselves or to intercept incoming insects.

Landscaping and Grounds Maintenance

Pest Barriers. Open areas. Discussion items for this topic should include: gravel foundation strips for rodent and other pest deterrence; mowed verges for tick control; pruning away tree limbs in contact with walls and removing climbing ivy to discourage ants and spiders; removing debris and dense vegetation, such as ivy and similar groundcover, to discourage rodents and snakes; mulch types and application in relation to invertebrate pest harborage, e.g. smoky brown cockroaches, millipedes. For more information contact the National Arborist Association, 174 Route 101, Bedford, NH 03102; CML 603-472-2255.

Fencing. Discussion items for this topic should include: deer exclusion fences; fencing techniques to exclude burrowing animals, e.g. "L" bend below groundline.

Other Exclusion Methods for Vertebrate Pests. Discussion items for this topic should include: planting bed surface and subsurface mesh; tree shields and collars to deter mouse, vole, rabbit, and deer feeding.

Playground Equipment and Design. Discussion items for this topic should include: rat deterrence principles for outdoor daycare space, e.g. pier-supported rather than slab-based play equipment, use of resilient synthetic surfacing rather than sand, mulch, or turf, some considerations for location, fencing, and plantings. For more information contact the National Recreation and Parks Association, 2775 South Quincy, Suite 700, Arlington, VA 22208; CML 703-820-4940.

Drainage. Discussion items for this topic should include: principles to reduce mosquito/midge breeding areas adjacent to structures.

Monitoring and Detection

Discussion items for this topic should include: capture for monitoring vs. control - see next section.

Sticky Traps for Cockroaches and Other Crawling Insects. Discussion items for this topic should include: designs and sizes; proper placement and use; baited or unbaited; warnings about supposed pheromone baits for German cockroaches; problems with nonremoval of these traps and occupant misconceptions of their purpose; the distinction between these traps and glue boards for mice; reference to electric cockroach trap models that have sticky sheets as a component.

Stored Product Insect Traps. Discussion items for this topic should include: various pheromone trap types & designs; light traps; deployment patterns & procedures.

Capture and Trapping

Vacuum Cleaners. Discussion items for this topic should include: their uses as "cleanout" tools for cockroaches; cleanup of termite and ant swarmers; immature flea control; removal of rodent droppings to aid in monitoring; capture of orb-weaving spiders and cleanup of webs; mini, portable, backpack, and shop models, specialized "suction samplers" (e.g. Johnson Southwood), and HEPA filter models; efficiency at capturing particles, capacity, cord vs. cordless, horsepower, attachments, cost; recommendations for disposal of contents. For more information, contact the International Sanitary Supply Association, 7373 North Lincoln Avenue, Lincolnwood, IL 60646-1799; CML 708-982-0800, Fax -1012.

Electric Traps for Cockroaches. Discussion items for this topic should include: warnings about needlessly elaborate commercial varieties of the Zap-Trap and Biocontrol Device; description of Roger Gold's coffee can research design.

Devices for Electrocuting Flying Insects. Emphasize indoor only. For detailed information, see Armed Forces Pest Management Board Technical Information Manual #25, *Devices for Electrocuting Flying Insects*, and Assistant Secretary of Defense (Production and Logistics)(Environment) Memorandum, *Policy on Electrically Operated Pest Control Devices*, 9 August 1988.

Non-Electric Trapping Devices for Flies. Discussion items for this topic should include: various flypaper products; homemade and commercial fruit fly and filth fly trap designs; a caution about purchasing the liquid bait sometimes sold with fruit fly traps, which is nothing more than malt vinegar.

Traps for Wasps and Hornets. Yellowjacket traps and honey bee swarm traps (from the low-tech fish-over-the-tub-of-water trick to the various commercial designs with attractant baits, yellowjacket traps catch lots of wasps but are usually ineffective for abatement; various designs of honey bee swarm traps and bait boxes may become important for Africanized bee abatement in some areas).

Rodent Glue Boards. Discussion items for this topic should include: types and techniques; caveat about animal rights groups.

Rodent Snap Traps. Discussion items for this topic should include: types and techniques.

Live Traps for Other Vertebrate Animals. Discussion items for this topic should include: windup, multiple-catch mouse traps; single-catch live traps for mice; short discussion about use of these traps vis-a-vis animal rights groups and the high mortality of captured mice; cage traps for other vertebrates, including birds; baiting and trap placement; techniques for disposal of captured animals; caveat about state and local laws.

Other Vertebrate Traps. Discussion items for this topic should include: gopher and mole traps; warn against use of "Batskat" device.

Bird Deterrence

General. A study of bird deterrent systems performed for the General Services Administration in 1980 found that audio repulsion (distress calls), scare systems (plastic owls, rubber snakes), and poisoning (baiting) have no long-term effects on pigeons and starlings in an urban environment. The study also found that tactile systems (sticky gel, porcupine wire, electric shock) are harmful to masonry as well as ineffective. A review report by the Air Force Bird Air Strike Hazard Team concluded that ultrasonic devices are ineffective because pest bird species cannot hear the wave-lengths of sound produced. Numerous other studies confirm these conclusions.

The attraction of birds must also be considered. Trash and garbage must be covered. Fish ponds and shallow pools of fresh water will attract birds to rest and feed. Transfer stations and trash holding areas must not be located near air fields or runways.

Recent advances in plastic netting and wire anti-roosting systems offer a potentially nondestructive solution for eliminating a variety of nesting and roosting habitats at historic buildings. Anti-roosting wire systems, also known as "pin and wire" and "trip wire," consist of a series of parallel wires of differing height, supported by narrow pins and held under tension by small springs to prevent pigeons from gaining a foothold on ledges. Plastic netting, initially developed for agricultural use, provides a vertical or horizontal barrier to areas where birds seek shelter and build nests. There are many types of netting and a variety of attachment methods. Only a few of these are acceptable for use on historic buildings.

VIII. TERMITE AND OTHER WOOD-DESTROYING INSECT CONTROL

Moisture Control

Discussion items for this topic should include: primary sources of structural moisture, soil contact, roof leaks, water flow off roof, wood seepage, prevailing rain, poor grade, plumbing leaks, condensation.

Moisture Meters

Moisture meters are excellent tools for determining the percent moisture content in such wood as siding, decking, joists and rafters, structural timbers, and utility poles. These portable devices give a direct reading when two probes are inserted into a wood member. A variety of moisture meters are available in prices ranging from $180 to $235 and are listed in supply catalogs for preservation, forestry and scientific equipment.

Electro-Gun

Discussion items for this topic should include: pimarily for localized infestations of drywood termites and other wood-destroying pests.

Cold Treatments

Discussion items for this topic should include: various liquid nitrogen systems, again primarily for localized infestations.

Heat Treatments

Based upon the principle that insects in any stage cannot survive if the temperature is raised to 155 degrees Fahrenheit. Possibly more appropriate as a separate section, since heat treatment may have broad application.

Sand Barriers

Basaltic sand particles that are carefully screened so that the particles are too large for termites to remove and too small for them to get between are an effective barrier to termites. These barriers should be at least four inches thick and treated with a long-lasting herbicide to prevent root penetration. Additionally, buildings protected by this method must be inspected periodically to ensure that termites have not "tubed" over the top of the barrier. The technique and the aggregate material are currently available in Hawaii.

Stainless Steel Screening

Stainless steel screening buried in the soil effectively prevents termite movement. It is a relatively expensive control but has the distinction of not introducing toxic materials into the soil.

Nematodes

Not recommended for protection against termites.

Detection Methods and Equipment

Discussion items for this topic should include: trained dogs, borescopes and other fiber optic devices, stethoscopes and other listening devices, e.g. Insecta-scope.

Treated Wood

Wood decomposes as the result of decay fungi feeding on it and is subject to damage from termites and other insects feeding on or burrowing through it. Simply preventing decay helps prevent insect damage because most insects are attracted to wood that has been softened by decay. Treating wood with preservatives prevents these problems from occurring in wood structures and buildings and is a subject most commonly addressed in the design process. Good design and construction practices for wood protection include:

- Protecting wood from absorbing moisture from the soil
- Protecting joints and end grains from water entry
- Promoting rapid run-off of rain water with roof overhangs and drip edges
- Supplying adequate ventilation for crawl spaces, attics and other places where water condenses on wood surfaces and
- Protecting finishes on all exposed wood

The Wood Protection Council of the National Institute of Building Sciences (NIBS) has developed an extensive document on wood protection - *Guidelines for Protecting Wood from Decay and Termites*. For more information, contact Wood Protection Council, National Institute of Building Sciences, 1201 L Street NW, Washington, DC 20055; (202) 289-7800. Detailed information on various aspects of wood protection is also available from a number of trade associations and government agencies:

American Plywood Association, P.O. Box 11700, Tacoma, WA 98411; (206) 565-6600.

American Wood-Preservers' Association, P.O. Box 286, Woodstock, MD 21163-0286; (410) 465-3169.

California Redwood Association, 405 Enfrente Drive, Suite 200, Novato, CA 94949; (415) 382-0662.

Cedar Shake and Shingle Bureau, 515 116th Avenue NE, Suite 275, Bellevue, WA 98004; (206) 455-1323.

National Forest Products Association, 1250 Connecticut Avenue NW, Washington, DC 20036; (202) 463-2700.

National Wood Window and Door Association, 1400 East Touhy Avenue, #G-54, Des Plaines, IL 60018; (708) 299-5200.

Southern Forest Products Association, Box 52468, New Orleans, LA 70152; (504) 443-4464.

Western Wood Products Association, 522 SW 5th Avenue, Yeon Bldg., Portland, OR 97204-2122; (503) 224-3930.

IX. ULTRASONIC, ELECTROMAGNETIC, AND OTHER ELECTRONIC DEVICES

Electromagnetic exclusion or control devices, ultrasonic repellent or control devices and outdoor devices for electrocuting flying insects should not be used on DoD installations. This does not apply to indoor use of selective devices for electrocuting flying insects when carried out in accordance with AFPMB Technical Information Memorandum No. 25, August 1988, Devices for Electrocution of Flying Insects. Pest surveillance traps and monitoring equipment, such as non-electrocuting mosquito light traps, may also be used by trained personnel. For additional information see:

References:

1. DASD(E, E & S) Memorandum, 30 March 78, Electromagnetic Devices for the Control of Pests.

2. AFPMB Memorandum, 16 April 82, Use of Electromagnetic, Ultrasonic, or Electrocution Devices.

3. DASD(E) Memorandum, 9 August 88, Policy on Electrically Operated Pest Control Devices.

4. U.S. Air Force Wright Laboratory Report WL-TR-2-3-33, April 92, Ultrasonics as a Method of Bird Control.